AMS-7

HEATER TESTS WITH WINTER SHIPMENTS OF MAINE POTATOES BY RAIL

January and February 1954

By

W. H. Redit, Mechanical Engineer
J. M. Lutz, Principal Horticulturist
Quality Maintenance and Improvement Section

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Biological Sciences Branch

Agriculture - Washington

January - 1955

CONTENTS

HEATER TESTS WITH WINTER SHIPMENTS OF MAINE POTATOES BY RAIL, JANUARY AND FEBRUARY 1954

Heater tests made early in 1954 to study the protection of Maine potatoes from freezing in transit during winter shipment were a continuation of the work begun during the previous winter.[1/] Their purpose was to obtain further information about the following: the effects of different types of car papering on potato temperatures in transit; the comparative performance of thermostatically controlled alcohol heaters, portable charcoal heaters, and underslung charcoal heaters; and the effect of car fans on heater performance and potato temperatures in transit.

PLAN AND PROCEDURE

A transportation test to Pittsburgh (test 1) was conducted in January, and a test to the New York City area (test 2) was run in February. Test 1 was conducted to compare nonfan cars with different papering methods and heaters. Test 2 was run to determine the value of charcoal and alcohol heaters and car fan operation. A list of the test cars together with the service and equipment used for each test is given in table 1.

Test Cars

Six of the cars used in test 1 were standard 40-foot end-bunker cars with wood sheathing, 2- to 3-inch insulation, 4-inch wooden floor racks and 3-foot hinged doors. They were all old cars of the BAR 6000, MDT 3000, and MDT 5000 series, rebuilt a number of years ago, but in fair condition and representative of many cars being loaded in Maine during the season. The seventh car was of the BAR 2000 series, the insulated boxcar developed for shipment of roll newsprint and used in potato shipments during the winter. This car contained 3 to 4 inches of insulation and was equipped with side-wall flues, a solid false floor (for paper loading), 6-foot sliding doors, and an underslung heater. As the inside dimensions (9' 2" x 40' 6") were greater than those of the standard refrigerator car, a special loading pattern was required for the 36,000-pound load normally used for potatoes.

In test 2, all cars were of the BAR 7000 series and were standard 40-foot end-bunker, steel-sheathed ones. They were equipped with electric fans in the upper bunker opening, 6-inch floor racks, and 6-foot sliding doors and contained 4 to 4 1/2 inches of insulation. Only fan cars were used so that they would be comparable in construction and condition. Where it was necessary to simulate nonfan conditions the fans were not operated.

Heaters

The portable charcoal heaters were the standard 14- and 16-inch sizes. The 16-inch heater was supplied with 40 pounds of charcoal while the 14-inch heaters

---

1/ H. T. & S. Office Report 297 "Tests of Railroad Protective Services for Winter Shipment of Maine Potatoes. Dec. 1952 to Feb. 1953."

were supplied with 20 pounds in test 1 and 30 pounds in test 2. The portable alcohol heaters were thermostatically controlled. The underslung charcoal heater was the same as used in previous tests. A description of both this heater and the alcohol heater may be found on pages 3 and 4 of H. T. & S. Office Report No. 297.

The heaters were all installed and fueled in the test cars at Northern Maine Junction prior to the preheating period. The 16-inch charcoal heater was placed in the A end of the car and the smaller one in the B, or brake, end. Both heaters were lit at the start of preheating. Normally, the cars are loaded on the day following the start of preheating. The small heater was not refueled and burned out in approximately 24 hours. The large heaters were either refueled at loading point or at Oakfield, Me., 6 to 12 hours after departure. However, in test 1, preheating was started on Friday, and the charcoal-heater cars were not loaded until Monday, necessitating refueling the 16-inch heaters on Sunday. Because of low temperatures in car C, the small heater was fueled with 15 pounds of charkets on Sunday and re-lit.

In this test a new type of charket with a starch binder, which gave out considerable smoke, was used. Because of this, the loaders moved the heaters from the bunkers in cars A and C to the top of the cars during the loading period. This undoubtedly affected their burning rate. Regular charkets were used in test 2. The thermostats on the alcohol heaters were set at 60° F. for preheating and reset at 45° when loading was started. Heaters were placed in both bunkers and burned for the duration of the tests.

The underslung heater in test 1 was lit at the same time as the others for preheating with the damper- or draft-setting at position 5. The following day it was opened to position 6 while the car was standing over the weekend and during loading. During transit it was set on position 5 to Mechanicsville, N. Y., and then set down to 3 for the rest of the trip.

The heaters were serviced at regular service points by regular heater personnel under the supervision of the test party. The amount of fuel added and consumed by the charcoal heaters was estimated on the basis of the number of 20-pound bags used and the fuel remaining in the heater. Fuel consumption of the alcohol heaters was based on fuel gage readings.

Temperature Records

Ten potato and two air temperatures in each test car were obtained by means of electric resistance thermometers installed prior to preheating. These connected to a master cable and the cable lead was conducted to the top of the car and fastened to the running board. Temperatures were read with a reading instrument into which the cable lead was plugged, every 6 to 10 hours at regular train stops or terminals.

The positions of the thermometers in the car and load were as follows: top bunker, centerline, head (TBCL-H) and rear (TBCL-R); top quarterlength centerline, rear (TQCL-R); top doorway centerline (TDCL); middle quarterlength, centerline, head (MQCL-H); bottom bunker, right side[2/] head (BBRS-H); bottom quarterlength,

---

2/ Right or left side facing forward end of car.

rightside, head (BQRS-H); bottom doorway right side (BDRS); bottom doorway left side[2/] (BDLS); bottom bunker, left side, rear (BBLS-R); top doorway, air (TD-air); bottom doorway, air (BD-air).

The top air position was 2 to 3 inches below the ceiling, while the bottom one was located in the air space under the floor rack. Both were in the centerline of the car. In the insulated box car, the bottom position was approximately 1 inch above the solid false floor. Potato temperatures were taken by inserting a thermometer during loading into an outside potato in the bag closest to the desired position. In the bottom positions this was in a potato next to the sidewall in a bottom-layer bag, and in the top positions it was in a potato at the top part of the bag. Temperatures during loading were taken with hand thermometers.

Loads and Loading Methods

Loading data for the cars in both tests are given in table 2. In test 1, it was necessary to split the loading over a weekend, 3 cars being loaded Saturday and the other 4 Monday morning. Each car was loaded without interruption. Portable blast heaters were used in the body of the cars for extra heating for 20 minutes to 3 hours just prior to loading except in the insulated box car, which received no supplementary heat. In test 2, the cars were loaded in a normal manner, 4 loaded completely the first day, 2 partially loaded the first day and finished the next morning, and 3 loaded completely on the second day. Blast heaters were used only in the 2 cars with no heaters.

All papering (fig. 1) was done by the regular loading crew under the supervision of the test party just prior to loading. However, in test 1 the paper under the floor racks was applied by the test party at Northern Maine Junction before preheating was started. The paper was the regular 250-pound kraft used in commercial loads. Canvas or burlap tunnels in varying stages of repair were used between the cars and the potato house doors during loading to exclude cold outside air from the cars. Temperatures over the weekend of loading in test 1 were low, reaching a minimum of 26° F. below zero on Monday morning.

In all test loads the potatoes were in 10-, 15- or 50-pound paper bags, or in 10-pound bags in 50-pound master containers. Some of the bags had mesh windows in one side. In nearly all cases, the potatoes were graded and bagged just prior to the loading operation, but some had been packed a day previously.

Routing

In test 1, the cars were routed via Bangor and Aroostock, Maine Central, Boston and Maine, Delaware and Hudson, and Pennsylvania railroads to Pittsburgh. The heaters were lit for preheating at 4 p.m. on January 15 at Northern Maine Junction, and the cars departed for the loading points at 11:10 p.m.

The cars were placed for loading during the following morning at Presque Isle, Brannon, and Mapleton. Loading was completed by noon of January 18 and the cars

---

2/ Right or left side facing forward end of car.

were assembled at Mapleton. The cars departed from Mapleton at 6:55 p.m. on that date and arrived at Pittsburgh at 3:30 a.m., January 22. Total elapsed transit time was 80 hours and 35 minutes, of which 38 hours and 5 minutes was running time (47.2 percent) and 42 hours and 30 minutes standing time (52.8 percent).

In test 2 the cars were routed via Bangor and Aroostook, Maine Central, Boston and Maine, and New York, New Haven and Hartford railroads to New York. Preheating was begun at Northern Maine Junction at 4 p.m. on February 16, and the cars departed for the loading points at 7:05 p.m. Three cars were separated from the group at Oakfield and went to Fort Fairfield in a separate train. The other cars arrived at Presque Isle at 3:30 a.m. Three proceeded to Caribou and two remained at Presque Isle for loading.

All cars were loaded on February 17 and 18. The Caribou and Presque Isle cars were assembled at Presque Isle and departed for New York at 5:45 p.m. The Fort Fairfield cars were met at Oakfield. The test train arrived at Oak Point, N. Y., (New York City) at 11:10 a.m. February 21, where the transit period was terminated and the cars were separated for delivery to Harlem River Yards and to Maspeth, L.I.

Because of the holiday weekend no attempt was made to expedite the movement, which was extremely slow. Elapsed transit time was 65 hours 25 minutes, of which 22 hours 40 minutes (34.7 percent) was running time and 42 hours 45 minutes (65.3 percent) was standing time. This is in contrast with an elapsed transit time of 38 hours 15 minutes for one test last year. The excessive standing time of test 2 must be considered in analyzing the effects of the car fans.

WEATHER

More nearly normal temperatures were encountered during loading in test 1 than in the previous winter's tests. Outside air temperatures during the preheating and loading periods ranged from -26° to +24° F. The average temperature during loading from noon January 16 to noon January 18 was about 0°. The first day in transit the temperatures ranged from -6° to +20° F., but thereafter the weather was warmer and the temperature varied from 20° to 50°. The average transit temperature was about 23° F. High winds and some snow were encountered during the loading period.

During the February test, the weather was much warmer, particularly during preheating and loading. The temperatures ranged from 25° to 34° F. during preheating, from 25° to 41° during loading, and from 4° to 55° in transit. The coldest weather occurred during the first night in transit after departure from Presque Isle and the maximum the following afternoon. The average transit temperature was about 34° F. Considerable snow was encountered during the loading period, but winds were only moderate. Outside air temperatures for both tests are shown graphically in figure 2.

RESULTS

Temperatures During Preheating Period

Loading over a weekend in test 1 made necessary an extended preheating period to which normal heater servicing was not geared. The weather was very cold at about the time the small charcoal heaters burned out, resulting in considerable drops

in temperature in cars A, B, and C (charcoal heater cars) during the second day at the loading point. Average top and bottom air temperatures are shown graphically in figures 3 and 4. In car C floor temperatures dropped to a point below freezing after 48 hours so that the small heater was refueled and lit.

Some rise in temperature before loading resulted. After the first 24 hours bottom temperatures in these 3 cars ranged from 47° to 59°, which would be satisfactory for loading. However, in the next 24 hours, after an outside temperature drop to below zero accompanied by high winds, there wasaconsiderable loss of heat before loading, as shown by the curves. One possible explanation for the more rapid temperature drop in car C was that it was fully exposed to the winds, while cars A and B were protected somewhat by the potato houses along the track.

Two of the alcohol-heater cars were loaded after 18 hours' preheating while the third was held over for 62 1/2 hours. The bottom air temperature rise in car E was 12° in 18 hours with a fuel consumption of 2.35 gallons, while the rise in car F was 19° with a fuel consumption of only 2.70 gallons. The average floor air temperatures in cars E and F at loading (26° and 33°, respectively) were too low for safe loading without the use of blast heat. In car D, which was preheated for 62 1/2 hours, the floor temperature reached a maximum of 41° after 42 hours and then dropped to 34° by loading time.

The underslung heater car (car G) was preheated for 18 hours during which time floor temperatures rose from 23° to 33°. Because of the low car temperatures, all cars except car G were blast-heated before loading. Only cars D (alcohol) and G were dry and free from frost at loading; the others had wet or frosted walls and frost on the floor-rack hinges.

More moderate temperatures were encountered during preheating in test 2 with outside air temperatures ranging from 25° to 34° F. and car temperatures averaging about 27° at the start. Both alcohol and charcoal heaters raised temperatures much higher than necessary, indicating that one heater would have been sufficient under the conditions encountered. However, as shown by the top temperatures of car B in figure 3, the action of the thermostat is shown in cutting off the heater after temperatures exceeded the setting.

Temperatures during the preheating period for the two cars with no heaters (G and H) are also shown in figures 3 and 4. The higher air temperature in car H was caused by a heater, placed in the bunker for emergency use, being inadvertently lit the day prior to preheating. This was not discovered until the first temperature reading before the other heaters were lighted. Although the heater was removed and the car aired by opening the doors and hatches, the temperature was not lowered to that of car G, by departure time. Car fans did not appear to reduce the temperature spread between top and bottom positions in these cars more than 2 or 3 degrees. A summary of the car air temperatures is given in table 3.

Effect of Papering Methods

In the 1952-53 season's tests in moderate weather, the regular method of lapping the floor rack paper up the side walls and sealing off the air space under the racks failed to keep the potatoes next to the floor racks warm. Leaving a 2- to 4-inch space along the juncture of rack and the wall unpapered or using paper under the floor rack to prevent air leakage at the juncture of side-wall and floor

resulted in temperatures 3° to 5° higher than in cars papered by the regular method.

In test 1 this season, with much colder weather, there was a slight difference in favor of modified papering when used with alcohol heaters (fig. 5) but practically no difference with charcoal heaters (fig. 6). As shown in figure 5, car D, with regular papering, was loaded during the cold spell and thus there was a much lower bottom potato temperature at the start of the transit period than in cars E and F. This was apparently due to leakage of cold air into the car through the door covering during loading. Temperature rise in transit was about the same in cars with regular and modified papering (5°), but it was about 7° for the cars with the paper lapped under the rack.

As all cars in test 2 were nearly new and in excellent condition and had tight wall construction, papering under the racks was not considered to be of advantage and was omitted. With the charcoal heaters, there was no difference in temperature between cars in which the regular and modified papering methods were used with the fans off (fig. 7). However, with fans operating, temperatures in the bottom of the load were 5° higher at destination when the modified papering method was used (fig. 8). A summary of average potato temperatures at the start of the transit period and upon arrival at destination for each test car is presented in table 3.

Heater Performance

The performance of the heaters was generally satisfactory insofar as actual burning was concerned. No heater went out for any reason except lack of fuel. Thermostat action on the alcohol heaters was apparently satisfactory, but one or two instances of fuel gages sticking temporarily were noted. Actual heat output varied somewhat for reasons which could not be determined. This was especially true of one alcohol heater in test 1. During the extended preheating of the cars in test 1, the 2 charcoal heaters warmed the cars very well until the small heater burned out during the cold spell.

One heater was not sufficient to maintain temperatures under those conditions. Because of the lower heat output, the alcohol heaters did not raise car temperatures sufficiently in 18 to 24 hours (fig. 4). However, in the car held over for 62.5 hours (car D) floor air temperatures were 34° at loading time despite the low outside temperatures. The underslung heater is inherently slow in starting to heat the car because of the large volume of liquid that must be initially heated. However, the car equipped with it was the only one in test 1 in which a blast heater was not used before loading because it was in excellent condition for loading. In addition, all walls and the floor were dry, and there was no evidence of frost inside the car.

To show the variation in the heat output of the two types of heaters and of individual heaters, the outputs in Btu (British thermal units) were calculated from the fuel consumption for the preheating period and the transit period (table 4). The average output of the alcohol heaters during the preheating period, when the heaters were on full burning, varied from 3410 to 4780 Btu per hour. Charcoal heater output ranged from 13,000 to 16,000 Btu per hour (1 to 1 1/4 lb. of fuel) during preheating but was less than 1 pound per hour in transit.

The effect of the thermostat action on reducing heat output when the heater is on pilot is clearly shown during the transit period in test 2 (table 4). The average heat output of each heater was about 1500 Btu per hour. During this same period, the average charcoal heater output was about 10,500 Btu per hour, much of it unnecessary because of high outside temperatures.

The generally higher potato temperatures in cars with charcoal heaters are shown in figures 9 and 10. In both tests, the top temperatures rose steadily in these cars as contrasted with the fairly constant level in cars with alcohol heaters because of the thermostatic action. The most uniform temperatures were again found in the underslung heater car (fig. 9), where the average top and bottom potato temperatures were never more than 2° apart.

Effect of Car Fans

The relatively mild weather and slow movement of the cars in transit in test 2 did not provide suitable conditions for a test of car fans. During preheating the average ceiling and floor air temperatures were lower in cars with fans on with charcoal heaters than it was in cars with fans off, as shown in figures 3 and 4. However, there was practically no difference between cars with alcohol heaters. The temperature spread between top and bottom was 12° to 16° and did not vary greatly between cars with fans on or off with either type of heater.

Average transit temperatures in cars with fans on and off with charcoal heaters with regular and modified papering are shown in figures 11 and 12. Top potato temperatures were lower in the cars with both types of papering with fans on than in those with fans off. The curves for car E in figure 12 clearly show how temperatures were raised at the bottom and lowered at the top when the fans were operated. The rapid temperature changes are not so apparent for car C (fig. 11) apparently because of more restricted air movement through the load when regular papering was used.

The temperature spread between top and bottom was 12° F. in the cars with fans on as compared with 22° in those with fans off. The spread would have been less than 12° in car C if the fans had operated a greater percentage of the time. Temperature differences between cars with alcohol heaters with fans on and off (fig. 13) were very small, mainly because of the thermostats which reduced the heat output. The effect of fans in maintaining higher bottom temperatures in cars without heaters is clearly shown in figure 14. A difference of 4° to 5° between cars was maintained during periods of movement. This is enough to provide much greater protection against freezing if very cold weather is encountered.

Wetting and Breakage of Bags

Although considerable moisture was found on the bags in some cars at destination, only 3 cars in test 1 had any breakage (table 5). Of these 3 only 1, with 61 broken 50-pound bags, had any serious damage, reported by the Railroad Perishable Inspection Agency (R P.I.A.) The other two cars had 6 and 11 broken bags, respectively. These three cars, D, E, and F, with alcohol heaters, had the lowest minimum temperatures upon arrival and the greatest amount of moisture on the bags.

The amount of breakage appeared to vary directly with the moisture observed. In test 1, the damp bags were in the lower layers and adjacent to the walls. In test 2, the cars had wall flues and the bags next to the walls were generally dry. More free moisture was noted in cars with fans on than in those with fans off.

Bag chafing was absent or very slight in all cars in both tests. All loads arrived in good order except for a few bags down in the doorway. Most of the trouble was from the ties slipping off the bags.

DISCUSSION

The results to date appear to indicate that two charcoal heaters, one in each bunker, will preheat refrigerator cars sufficiently for safe loading within a 24-hour period. In mild weather, one heater probably would be sufficient. If loading is delayed longer than 24 hours in very cold weather, both heaters should be refueled. Two alcohol heaters will not be sufficient to warm cars adequately in extremely cold weather if only 18 to 24 hours is available for preheating. In mild weather, two will generally be sufficient.

One advantage of alcohol heaters is that refueling should not be necessary for about 48 hours. This is time enough during normal operations for the cars to be loaded and returned to the first servicing point. Thermostats should be set at 60° F. for preheating and reset at 45° after loading is completed. The underslung heater requires a minimum of 24 hours to preheat a car properly in very cold weather, as it takes considerable time to warm the heating coil and liquid initially. Since heat is applied at the floor level, floor air temperatures do not have to be as high as when the portable bunker type heaters are used.

Cars that show frost on walls or floor-rack hinges after preheating should be heated further with a portable car heater. The type using a fan for horizontal distribution of the heated air should be used, as the blast type overheats the ceiling and scorches and blackens the car lining.

Cold air should be prevented from entering the car during the loading operations. Great care should be taken in attaching the car shield or tunnel to eliminate possible air leaks. Canvas with tears or holes should be repaired or replaced. If cold air is allowed to enter, the temperature of potatoes on the floor may be lowered to near the freezing point or even lower before the doors are closed. This lowering undoubtedly is an important factor in freezing damage in transit.

An example of this condition is shown in the records of cars A, B and D in test 1 (table 3). Here the lowest commodity temperatures immediately after loading were 4° to 10° lower than the potato temperatures taken with a hand thermometer during the loading operation (table 2).

With proper servicing en route the charcoal, alcohol, and underslung heaters provide adequate protection in transit if potato temperatures in the bottom center of the load are 40° F. or above when the car is closed after loading. In very cold weather, two charcoal heaters should be used. Present methods of lighting charcoal heaters sometimes raise temperatures higher than necessary and waste fuel. The result is that probably under very severe weather conditions sufficient protection is not given. It is suggested that the lighting and extinguishing of the heaters be based on outside temperatures.

With the thermostat set at 45°, the alcohol heater will not overheat the potatoes and will use only a minimum of fuel in mild weather. Two heaters will probably be sufficient for maintaining temperature under most Maine weather conditions. Proper attention to the car thermometer in the manipulation of the draft on the

underslung heater will prevent overheating and fuel waste.

The use of the modified papering method in which the paper is lapped under the floor racks and up the car walls to stop the entrance of cold air in older cars results in somewhat higher temperatures in the bottom layer. Extra labor is required in applying paper under the racks. With the modified method with a space between the wall and the racks the paper may be laid lengthwise of the car regardless of whether or not paper is used under the racks. This way is quicker and requires less paper than laying strips crosswise and up the sides as is done in the regular method.

Floor-rack hinges should be covered with 2 layers of paper. Loose-fitting doors should be papered to prevent drafts, and the paper used for doors should be extended under the racks in the doorway area. In cars with wall flues, the modified method is not so important, as air can circulate under the racks and through the flues.

Car fans should always be operated when either charcoal or alconol heaters are used, but it is especially important that they operate if no heat is applied. Although the fans are not as effective in the tight bag loads used in Maine as in more open loads, they do improve transit temperatures. As most of the newer fan cars also have wall flues, proper air circulation is more easily maintained than in cars with no flues. Car fans reduce top and raise bottom load temperatures and also permit the thermostat to control air temperatures more closely when alcohol heaters are used.

SUMMARY

Two transportation tests were conducted as a continuation of the studies of protective services available for the rail shipment of potatoes from Maine to eastern markets. In the January and February 1954 tests 15 test cars were included. Data were obtained on the following: the performance of portable charcoal, thermostatically controlled alcohol, and underslung charcoal heaters for preheating the cars and protection of potatoes in transit; the effects of different methods of lining the cars with paper; and the effects of car fans on potato temperatures and heater performance.

About-normal winter weather was encountered in January, but temperatures were much higher during the February test.

Two alcohol heaters did not raise car air temperatures sufficiently in very cold weather in the usual time alloted for the preheating operation. Two charcoal heaters were satisfactory for preheating cars under normal loading conditions. However, when the cars were held over for 2 extra days in very cold weather, the usual practice of permitting one heater to burn out resulted in air temperatures in the cars lower than considered safe for loading. The underslung charcoal heater was satisfactory, but more than 24 hours should be allowed for preheating in severe weather.

During transit, all heaters protected the potatoes from freezing, but higher temperatures than necessary were found in the loads protected by the portable charcoal heaters. Lower and more uniform temperatures resulted from the use of the thermostatically controlled alcohol heaters and the underslung charcoal

heater. Better all-round performance was given by the alcohol heaters during mild weather because of the thermostatic control.

A new type of fuel for the charcoal heaters, which contained a starch binder to form the charkets, gave off considerable smoke, which interfered with the work of the loading crew.

Poor condition of the loading shields between the car and potato houses during the loading period resulted in a loss in temperature of nearly 10° F. in potatoes placed on the floor, because of the entrance of cold air into the car.

Practically no difference in temperatures in potatoes in the bottom of the load was obtained when the regular papering method was modified to leave an air space of 2 to 4 inches between the edge of the floor racks and the side walls. However, using this method and extending the sidewall paper to the floor and lapping it under the floor racks for 6 to 8 inches resulted in slightly higher temperatures. The modification was to stop possible air leaks along the juncture of floor and wall in older cars in poor condition. The modified papering method was most effective in providing more uniform temperatures when car fans were used.

The use of car fans with and without heaters resulted in somewhat more uniform temperatures in the load. In cars without heat, the use of fans resulted in temperatures 4° to 5° higher in the bottom of the load. This difference could have been important in preventing freezing under severe weather conditions.

Bag breakage was slight and appeared to be affected by the amount of bag wetting through condensation. There was less condensation in cars equipped with wall flues, but fans did not reduce bag wetting. Applying heat to the car under the floor racks as done in the underslung heater cars resulted in very little moisture deposition.

ACKNOWLEDGEMENTS

These tests were made possible by the cooperation of many individuals and organizations, and grateful acknowledgment and thanks are hereby expressed to the following:

Dr. C. H. Merchant, Head, Department of Agricultural Economics, University of Maine, Orono, for assistance in planning and Merton Parker, University of Maine, Washburn, Me., for assistance in loading the test cars.

Frank D. O'Brien, Manager of Car Service, Bangor and Aroostook Railroad, for assistance in the general planning of the tests, arranging for accommodations and transportation for the test parties, providing the test cars, and facilitating the handling of the test cars on all railroads concerned.

E. A. Bowen, also of the Bangor and Aroostook Railroad, for special assistance in preparing, loading and unloading the test cars and during the transit period and Norman Tardiff, John Hall and Sam Ruth for assistance in routing and loading the test cars.

E. T. Leach, General Manager, Maine Potato Shippers Heater Service, for assistance of personnel and use of facilities. Heater Service personnel assisting in loading were Stanley Greaves and Art Bezanson.

The Maine Central, Delaware and Hudson, Pennsylvania, and New York, New Haven and Hartford Railroads for furnishing accommodations and transportation and the Boston and Maine Railroad for furnishing transportation for the test parties and special handling of the test cars at terminals.

The Atlantic Commission Co. (National Produce Division, The Great Atlantic and Pacific Tea Co.) for furnishing loads for the test cars through Doug Grant, Presque Isle.

S. A. Cole, Preco, Inc., for assistance in preparing cars and heaters and in the loading of the test cars.

M. S. Weatherhead, Fruit Growers Express Co., for help in unloading test cars in Pittsburgh.

J. E. Basn, District Inspector, The Railway Perishable Inspection Agency, Pittsburgh, for inspection report on cars in test 1.

W. A. Radspinner and H. W. Hruschka, U. S. Department of Agriculture, New York, for assistance in unloading in the New York area.

Members of the test party were E. A. Bowen, Bangor and Aroostook Railroad, Oakfield, Me., both tests; M. S. Weathernead, Fruit Growers Express, Alexandria, Va., from Wilkes-Barre to Pittsburgh, test 1; J. M. Lutz, U. S. Department of Agriculture, New York, both tests; W. H. Redit, U. S. Department of Agriculture, Beltsville, Md., both tests; and C. O. Bardo, New York, New Haven and Hartford R.R., Boston, from Worcester, Mass., to New York in test 2.

Table 1

List of Cars, Protective Services and Equipment Used in Heater Tests with Maine Potatoes, 1954

Test and car No.	Type of heater	Car fans	Method of papering 1/	Type of containers
Test 1:				
A (MDT 5687)	Charcoal	-	Regular	50-lb. bag
B (MDT 5506)	Charcoal	-	Modified	10-lb. bag 2/
C (BAR 6591)	Charcoal	-	Under floor racks	15-lb. bag
D (MDT 5969)	Alcohol	-	Same as A	50-lb. bag
E (MDT 3136)	Alcohol	-	Same as B	50-lb. bag
F (BAR 6001)	Alcohol	-	Same as C	15-lb. bag
G (BAR 2406)	Underslung	-	Same as A	15-lb. bag
Test 2:				
A (BAR 7518)	Alcohol	On	Regular	10-lb. bag
B (BAR 7243)	Alcohol	Off	Regular	10-lb. bag
C (BAR 7051)	Charcoal	On	Regular	10-lb. bag
D (BAR 7332)	Charcoal	Off	Regular	15-lb. bag
E (BAR 7631)	Charcoal	On	Modified	10-lb. bag
F (BAR 7371)	Charcoal	Off	Modified	50-lb. bag
G (BAR 7686)	-	On	Regular	10-lb. bag
H (BAR 7608)	-	Off	Regular	50-lb. bag

1/ Papering Methods: Regular - 2 layers over floor racks lapped up side walls 3' to 5'.
Modified - same as regular except that 2" to 4" space was left on racks at side walls.
Under floor racks - same as modified except that side wall paper is lapped under floor racks for 6" to 8" from side walls

2/ 5 10-lb. bags placed in a master bag for loading.

Table 2

Loading Data For Heater Tests With Maine Potatoes, 1954

Test and car No.	Car fans	Type of heater	Loading date (1954)	Loading point, Maine	Time of loading	Outside air temperature range (°F.)	Average car air temperature: Top (°F.)	Average car air temperature: Bottom (°F.)	Average potato temperature (°F.)	Package size (lb.)	Package No.	Hours of blast heat before loading
Test 1:												
A	-	Charcoal	Jan. 18	Mapleton	6:15 - 10:15 a.m.	-22 to -8	42.3	25.4	39 to 42	50	720	2
B	-	Charcoal	Jan. 18	Presque Isle	7 - 10:40 a.m.	-22 to -10	50.0	33.0	40 to 42	10 1/	720	1/3
C	-	Charcoal	Jan. 18	Brannen	8 - 11 a.m.	-18 to -8	50.2	32.2	41 to 44	15	2400	3
D	-	Alcohol	Jan. 18	Mapleton	8 - 11 a.m.	-18 to -8	44.0	34.0	37 to 44	50	720	1/2
E	-	Alcohol	Jan. 16	Brannen	1:45 - 3:15 p.m.	18	36.2	26.1	38 to 42	50	720	2
F	-	Alcohol	Jan. 16	Mapleton	1:30 - 3:30 p.m.	14	55.0	33.3	36 to 42	15	2400	1 1/4
G	-	Underslung	Jan. 16	Presque Isle	10:30 a.m. - 2:45 p.m.	15	36.3	32.6	38 to 40	15	2400	0
Test 2:												
A	On	Alcohol	Feb. 17	Presque Isle	9 a.m. - 3:15 p.m.	29 to 30	63.4	51.2	36 to 42	10	4000	0
B	Off	Alcohol	Feb. 18	Ft. Fairfield	9:50 a.m. - 2:15 p.m.	39 to 41	62.0	47.3	39 to 41	10	4000	0
C	On	Charcoal	Feb. 17	Caribou	1:20 - 4 p.m.	30 to 36	80.5	66.0	35 to 38	10	4000	0
D	Off	Charcoal	Feb. 17 Feb. 18	Presque Isle	3:15 - 5 p.m. 7 - 9:15 a.m.	25 to 31	92.8	76.9	40 to 41	15	2650	0
E	On	Charcoal	Feb. 17, 18	Ft. Fairfield	4 p.m. - 9:45 a.m.	28 to 31	78.7	62.4	35 to 40	10	4000	0
F	Off	Charcoal	Feb. 17, 18	Ft. Fairfield	3:30 p.m. - 7:30 a.m.	28 to 30	92.5	77.0	38 to 45	50	800	0
G	On	-	Feb. 18	Caribou	7:30 - 11 a.m.	28 to 34	30.7	29.7	39 to 40	10	4000	2 1/2
H	Off	-	Feb. 17	Caribou	1:30 - 4 p.m.	30 to 36	36.9	37.1	41 to 43	50	800	2 1/2

1/ 5 10-lb. bags placed in master bag.

Table 5

Summary of Air and Potato Temperatures (°F.) in Heater Tests with Maine Potatoes, 1954

Test and car No.	Car fans	Type of heater	Method of papering[1]	Preheating period (air)								Transit period[2] (potato)									
				Range of outside air temperature	Condition of car end of period	Average top				Average bottom				Range of outside air temperature	Average top			Average bottom				Car averages			
						Start	Finish	Diff.		Start	Finish	Diff.			Start	Finish	Diff.	Start	Finish	Diff.		Start	Finish	Diff.	
Test 1:																									
A[3]	-	Charcoal	Regular	-22 to 24	Slight frost on hinges	16.3	41.9 (61.7)[4]	25.6		14.1	25.4 (44.5)[4]	11.3		-6 to 50	43.0	62.1	19.1	36.8	47.0	10.2		39.9	54.6	14.7	
B[3]	-	Charcoal	Modified	-16 to 24	Frost on 1 hinge	17.2	50.0 (82.3)[4]	32.8		14.7	38.0 (59.0)[4]	23.3		-6 to 50	44.1	62.8	18.7	35.8	45.6	9.8		40.0	54.2	14.2	
C[3]	-	Charcoal	Under rack	-26 to 24	Frost on hinges	16.6	50.2 (74.2)[4]	33.6		14.9	32.2 (57.2)[4]	17.3		-6 to 50	51.5	62.3	10.8	43.9	46.4	2.5		47.7	54.4	6.7	
D[3]	-	Alcohol	Regular	-22 to 24	Dry, no frost	21.1	50.6	29.5		17.8	34.4	16.6		-6 to 50	46.4	49.9	3.5	30.7	35.0	4.3		38.6	42.5	3.9	
E	-	Alcohol	Modified	-6 to 24	Frost on walls	16.3	36.2	19.9		14.4	26.1	11.7		-23 to 50	49.9	50.9	1.0	43.7	38.7	-5.0		46.8	44.8	-2.0	
F	-	Alcohol	Under rack	-6 to 24	Walls wet; no frost	15.5	44.0	28.5		14.4	33.2	18.8		-26 to 50	50.5	55.0	4.5	40.6	41.4	0.9		45.5	48.2	2.7	
G	-	Underslung[5]	Regular	-6 to 24	Dry, no frost	27.1	36.3	9.2		23.6	32.6	9.0		-22 to 50	41.0	44.0	3.0	41.1	45.1	4.0		41.1	44.6	3.5	
Test 2:																									
A	On	Alcohol	Regular	25 to 34	Dry	27.8	63.4	35.6		26.5	51.2	24.7		4 to 55	43.0	48.2	5.2	39.6	45.4	5.8		41.3	46.8	5.5	
B	Off	Alcohol	Regular	25 to 34	Dry	29.1	62.0	32.9		29.2	47.3	18.1		4 to 55	42.1	48.6	6.5	39.6	42.6	3.0		40.9	45.6	4.7	
C	On	Charcoal	Regular	25 to 34	Dry	29.1	80.5	51.4		27.8	66.0	38.2		4 to 55	50.3	61.1	10.8	37.8	49.2	11.4		44.1	55.2	11.1	
D	Off	Charcoal	Regular	25 to 34	Dry	28.0	92.8	64.8		27.2	76.9	49.7		4 to 55	56.3	70.4	14.1	45.2	53.7	8.5		50.8	62.1	11.3	
E	On	Charcoal	Modified	25 to 34	Dry	27.6	78.7	51.1		26.8	62.4	35.6		4 to 55	49.0	66.1	17.1	38.3	54.2	15.9		43.7	60.2	16.5	
F	Off	Charcoal	Modified	25 to 34	Dry	29.3	92.5	63.2		27.7	77.0	49.3		4 to 55	58.1	72.0	13.9	45.0	49.4	4.4		51.6	60.7	9.1	
G	On	-	Regular	25 to 34	-	29.5	30.7	1.2		27.9	29.7	1.8		4 to 55	41.7	42.7	1.0	38.5	42.1	3.6		40.1	42.4	2.3	
H	Off	-	Regular	25 to 34	-	37.1	36.9	-0.2		36.6	37.1	1.4		4 to 55	47.5	42.2	-5.3	39.4	39.8	0.4		43.5	41.0	-2.5	

1/ Regular papering - 2 layers over floor racks lapped up side walls 3' to 5'.
Modified papering - same as regular except that 2" to 4" space was left on racks at side walls.
Under floor racks - same as modified except that side wall paper was lapped under floor rack for 6" to 8" from side walls.

2/ Period from end of preheating to 7 1/2 hours after arrival at Pittsburgh for test 1 and until arrival at Oak Point, N.Y. for test 2.

3/ Loaded on Jan. 18; other cars loaded Jan. 16.

4/ Maximum temperatures during preheating in cars A, B and C occurred on Jan. 17 and are shown in parentheses.

5/ Heater burned out Jan. 17 but was re-lit on that date.

Table 4

Heater Fuel Consumption and Burning Rate in Heater Tests with Maine Potatoes, 1954

Test and car No.	Car fans	Type heater	Method of papering[1]	Preheating period: No. of heaters[2]	Preheating period: Fuel consumed	Preheating period: Duration (hours)	Preheating period: Rate burning per hour	Preheating period: Total Btu per hour[3]	Preheating period: Btu per hour per heater	Transit period[6]: No. of heaters[4]	Transit period[6]: Fuel consumed	Transit period[6]: Duration (hours)	Transit period[6]: Rate burning per hour	Transit period[6]: Total Btu per hour	Transit period[6]: Btu per hour per heater	Total fuel consumption: Fuel used	Total fuel consumption: Total time (hours)	Total fuel consumption: Total cost[5] (dollars)	Cost per hour (cents)
Test 1:																			
A	-	Charcoal	Regular	2	90 lb.	62	1.45 lb.	18,900	- [7]	1	70 lb.	101	0.69 lb.	8,970	8,970	180 lb.	163	7.20	4.4
B	-	Charcoal	Modified	2	80 lb.	81	1.31 lb.	17,000	- [7]	1	115 lb.	102	1.13 lb.	14,690	14,690	195 lb.	183	8.78	5.4
C	-	Charcoal	Under rack	2	95 lb.	82	1.21 lb.	15,700	- [7]	1	75 lb.	101	0.74 lb.	9,520	9,620	170 lb.	153	7.85	4.7
D	-	Alcohol	Regular	2	6.7 gal.	62.5	0.107 gal.	8,820	3,410	2	13.4 gal.	100.5	0.134 gal.	8,550	4,276[8]	20.1 gal.	183	10.13	8.2
E	-	Alcohol	Modified	2	2.36 gal.	18	0.13 gal.	8,280	4,140	2	15.8 gal.	145	0.109 gal.	5,950	3,475[8]	18.15gal.	153	9.15	5.8
F	-	Alcohol	Under rack	2	2.7 gal.	15	0.15 gal.	9,550	4,780	2	19.2 gal.	145	0.132 gal.	8,420	4,210[8]	21.9 gal.	163	11.04	8.8
G	-	Underslung	Regular	1	35 lb.	18	1.94 lb.	25,200	25,200	1	170 lb.	145	1.17 lb.	15,210	15,210	205 lb.	163	9.23	5.7
Test 2:																			
A	On	Alcohol	Regular	2	2.45 gal.	17	0.144 gal.	9,150	4,575	2	4.95 gal.	99.5	0.050 gal.	3,180	1,590[8]	7.40 gal.	116.5	3.73	3.2
B	Off	Alcohol	Regular	2	5.00 gal.	40	0.125 gal.	7,950	3,975	2	3.30 gal.	75.5	0.043 gal.	2,740	1,370[8]	8.30 gal.	118.5	4.18	3.6
C	On	Charcoal	Regular	2	27 lb.	20	1.35 lb.	17,550	- [7]	1	73 lb.	95.5	0.76 lb.	9,880	9,880	100 lb.	116.5	4.50	3.9
D	Off	Charcoal	Regular	2	42 lb.	21.5	1.95 lb.	25,400	- [7]	1	55 lb.	96.0	0.58 lb.	7,550	7,550	110 lb.	115.5	4.95	4.3
E	On	Charcoal	Modified	2	29 lb.	23.0	1.28 lb.	16,400	- [7]	1	107 lb.	93.5	1.15 lb.	14,950	14,950	135 lb.	115.5	5.12	5.3
F	Off	Charcoal	Modified	2	38 lb.	23.0	1.65 lb.	20,450	- [7]	1	70 lb.	93.5	.75 lb.	9,750	9,750	110 lb.	115.5	4.95	4.3

1/ Papering Methods: Regular - 2 layers over floor racks lapped up sidewalls 3' to 5' (See Fig. 1).
Modified - same as regular except that 2" to 4" space was left on racks at side walls.
Under rack - same as modified except that sidewall paper was lapped under floor racks for 6" to 8" from sidewalls.

2/ During preheating, 1-18" and 1-14" charcoal heater or 2 alcohol heaters with thermostats set at 60° F. burning.

3/ Based on heat value of 13,000 Btu (British thermal units) per pound for charkets and 83,700 Btu per gallon for alcohol.

4/ While under load during transit, 1 16" charcoal heater or 2 alcohol heaters with thermostats set at 45° F. were burning.

5/ Period from end of preheating to 7 1/2 hours after arrival at Pittsburgh for test 1 and until arrival at Oak Point, N. Y. for test 2.

6/ Based on a cost of charkets at 45 cents per pound and 50.4 cents per gallon for alcohol.

7/ Not possible to determine because 2 different-sized heaters were used with no record of burning time of small heater.

8/ Alcohol heaters on pilot part of time by thermostatic action.

Table 5

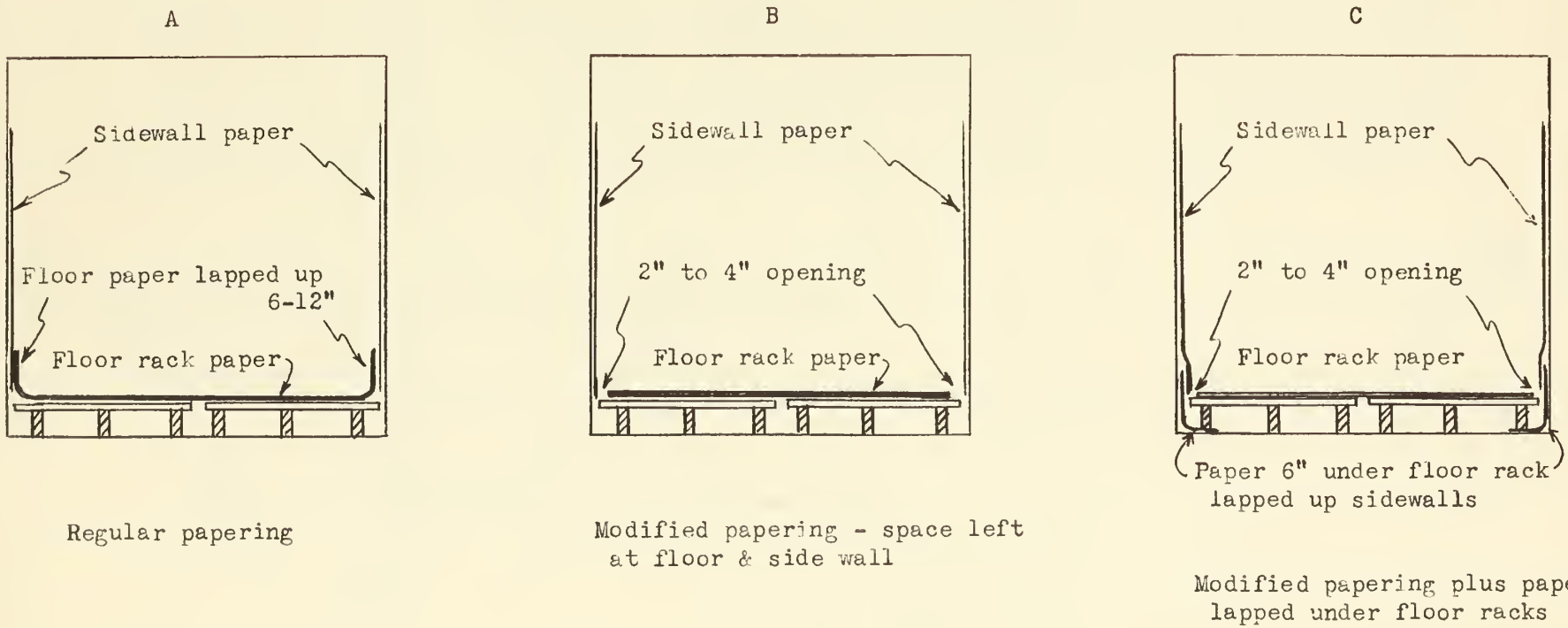
Unloading Data For Heater Tests With Maine Potatoes, 1954

Test and car No.	Car fans	Type of heater	Unloading dates (1954)	Time of unloading	Shifting of load	Number of bags broken	Bag chafing	Moisture on bags	Freezing injury
Test 1:									
A	-	Charcoal	Jan. 25	1/	None	0	Very slight	Very slight	None
B	-	Charcoal	Jan. 22	11 p.m. - 4 a.m.	Slight in doorway	0	None	None	None
C	-	Charcoal	Jan. 22	6:30 - 11 p.m.	None	0	Very slight	Very slight	None
D	-	Alcohol	Jan. 25	1/	None	6	Very slight	Slight	None
E	-	Alcohol	Jan. 25	1/	None	61	Very slight	Considerable free at walls	None
F	-	Alcohol	Jan. 23	1 - 4 a.m.	None	11	Very slight	Considerable free except in upper 2 layers	None
G	-	Underslung	Jan. 24, 25	9:30 p.m. - 1:30 a.m.	None	0	None	Very slight	None
Test 2:									
A	On	Alcohol	Feb. 24	7 a.m. - noon	None	4	Very slight	None along walls (considerable in load)	None
B	Off	Alcohol	Feb. 23	9 p.m. - 2/	None	0	Very slight	Considerable	None
C	On	Charcoal	Feb. 22, 23	9 p.m. - 2/ a.m.	None	0	Very slight	Considerable below 2nd layer (free)	None
D	Off	Charcoal	Feb. 24	4 p.m. 2/	None	1	Very slight	Slight	None
E	On	Charcoal	Feb. 24	7 a.m. - noon	None	3	Very slight	None along walls (free in load)	None
F	Off	Charcoal	Feb. 23	9 p.m. - 2/	None	0	Slight	Considerable with free	None
G	On	None	Feb. 22	9 p.m. - 2/	None	0	Very slight	Very slight	None
H	Off	None	Feb. 23	9 p.m. - 2/	Slight shift one end	0	Very slight	Very slight	None

1/ Equipment removed before unloading.
2/ No record of finish of unloading.

Figure 1

Method of papering cars in Maine potato heater tests, 1954



Regular papering

Modified papering - space left at floor & side wall

Modified papering plus paper lapped under floor racks

Figure 2

Outside air temperatures for tests 1 and 2,
Maine potato heater tests, 1954

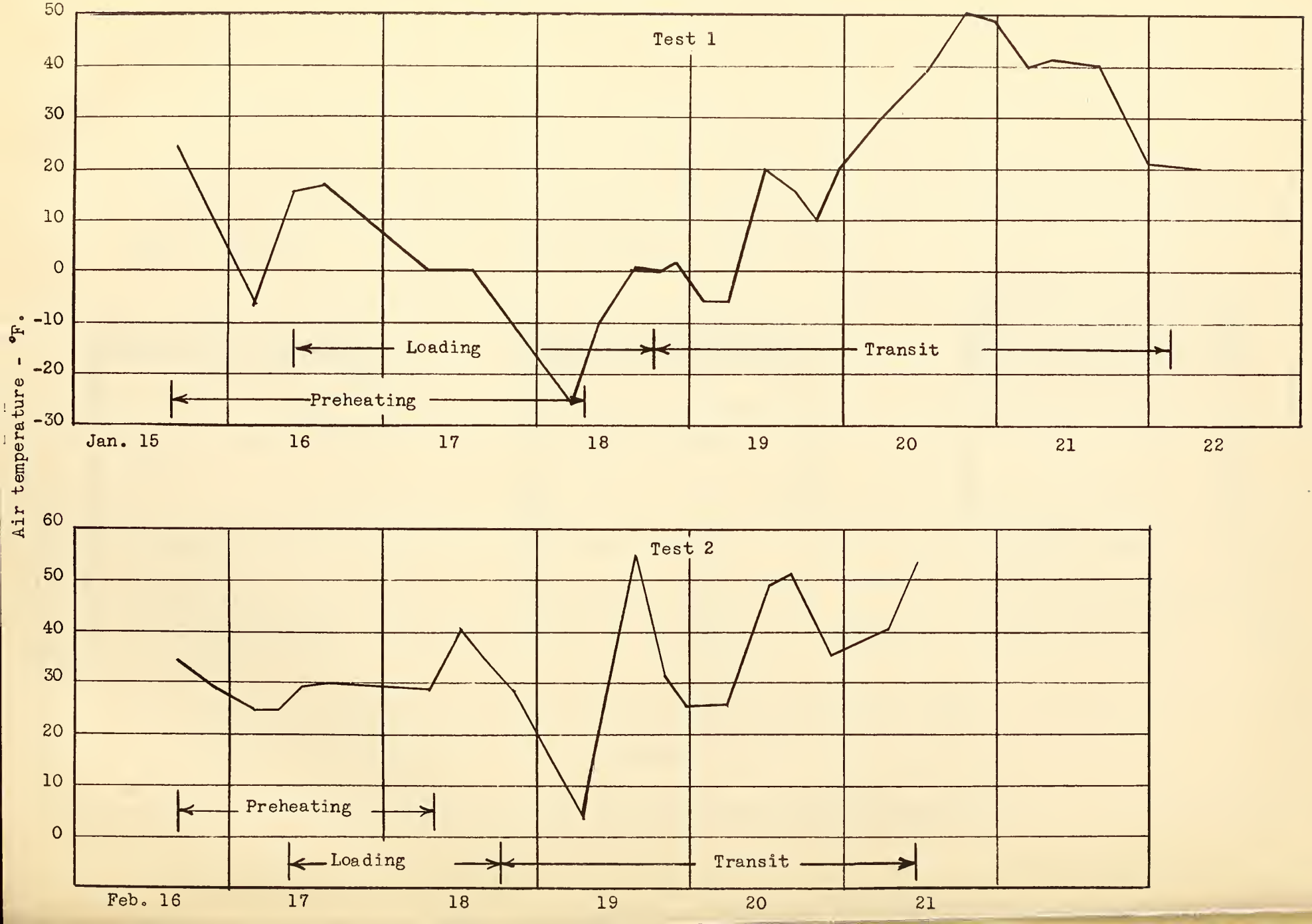


Figure 3

Comparison of average air temperatures at ceiling during preheating: Non-fan and fan cars with charcoal, alcohol and underslung heaters.

Tests 1 and 2

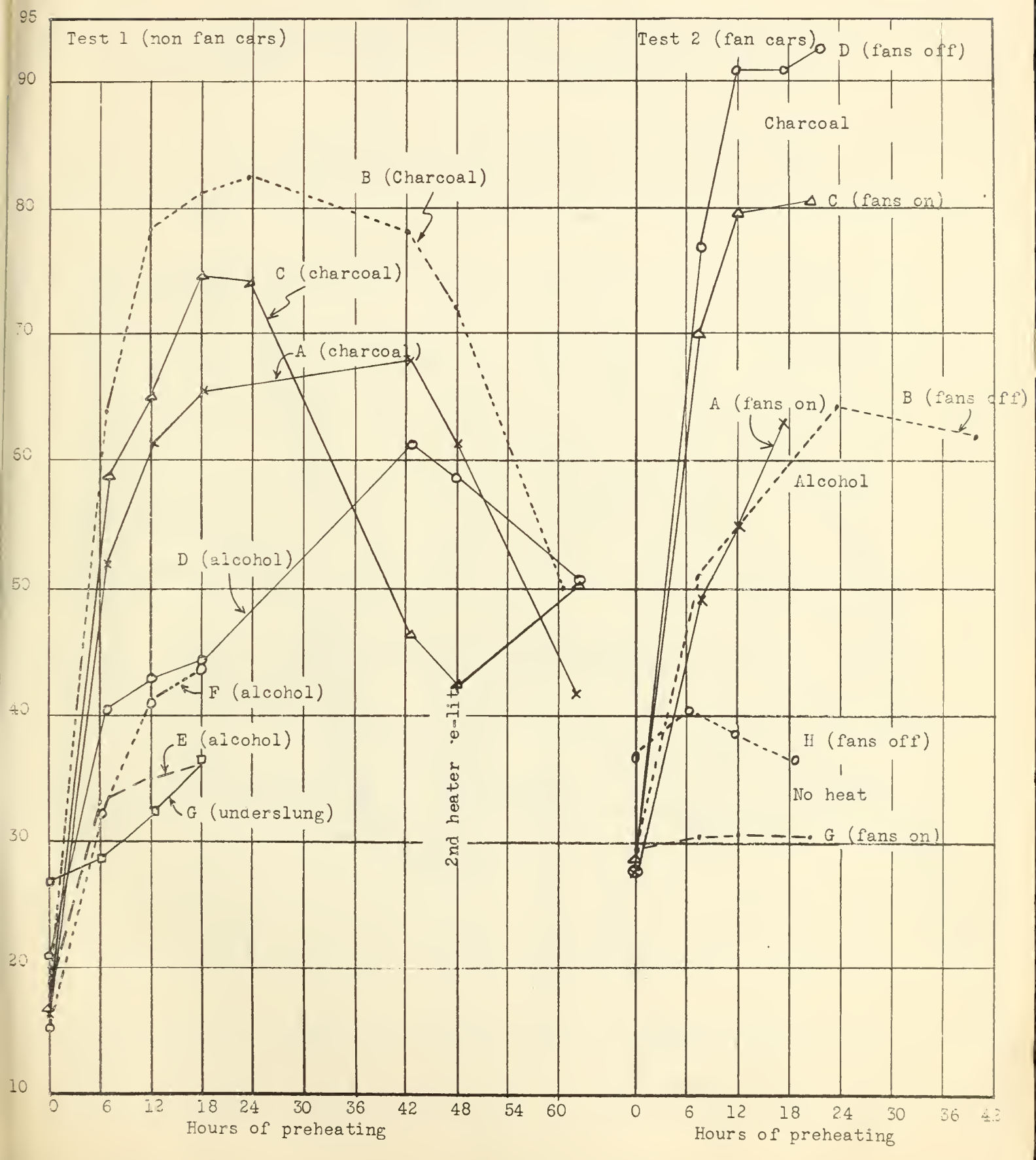


Figure 4

Comparison of average air temperatures at floor during preheating: Non fan and fan cars with charcoal, alcohol and underslung heaters.

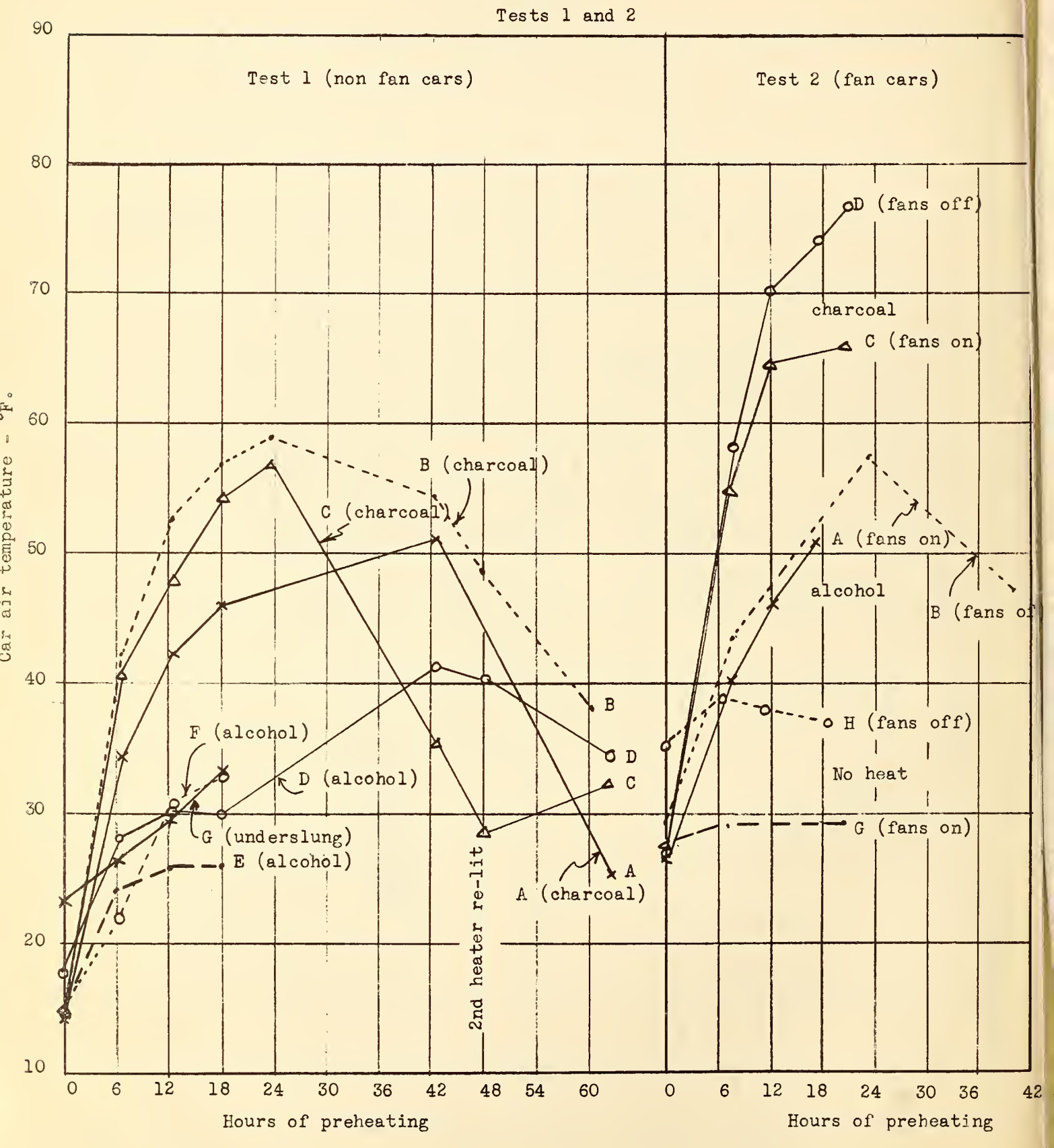


Figure 5

Comparison of average bottom layer potato temperatures in transit:
Regular and modified papered non-fan cars
with alcohol heaters

Test 1

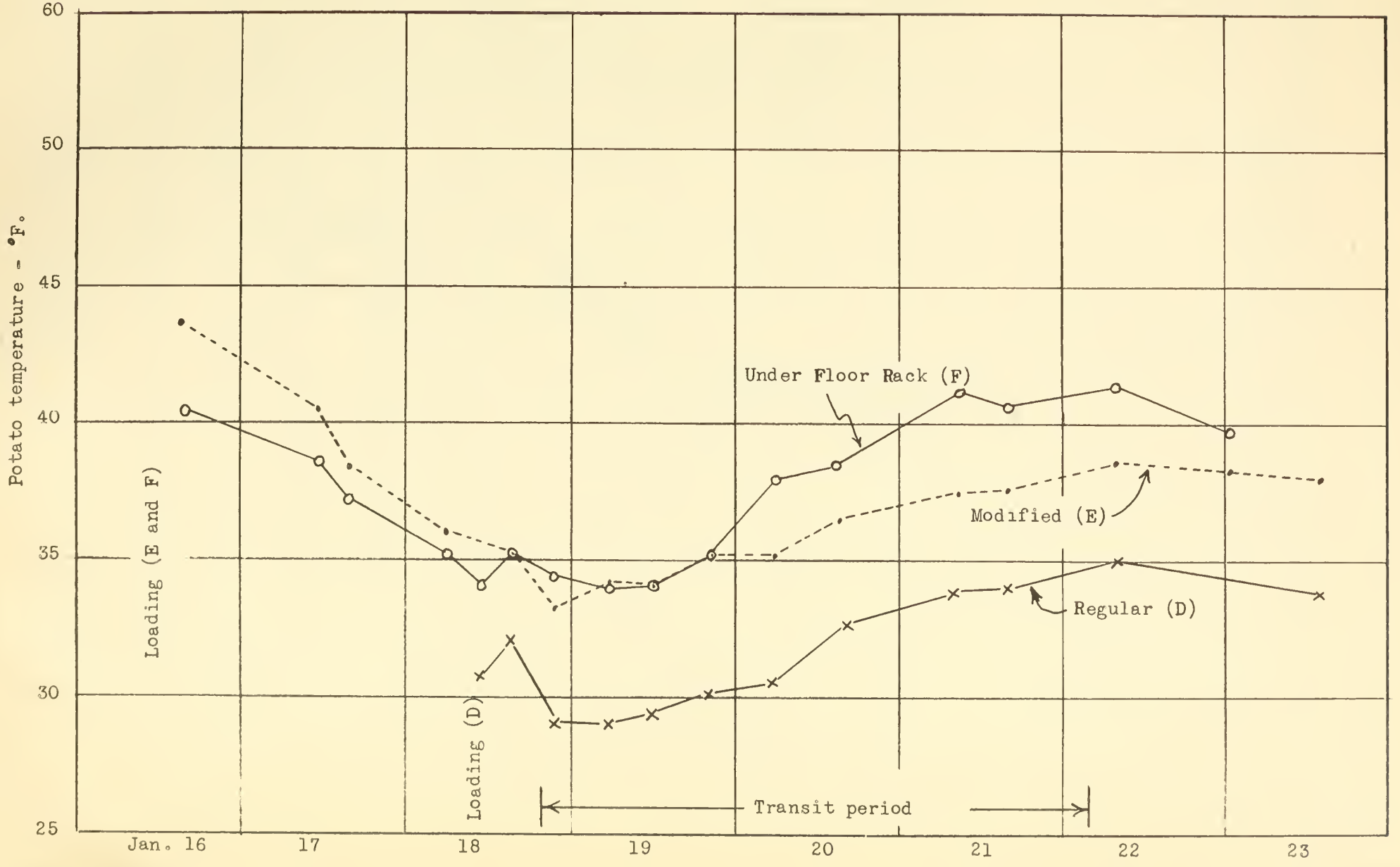


Figure 6

Comparison of average bottom layer potato temperatures in transit:
Regular and modified papered non-fan cars
with charcoal heaters

Test 1

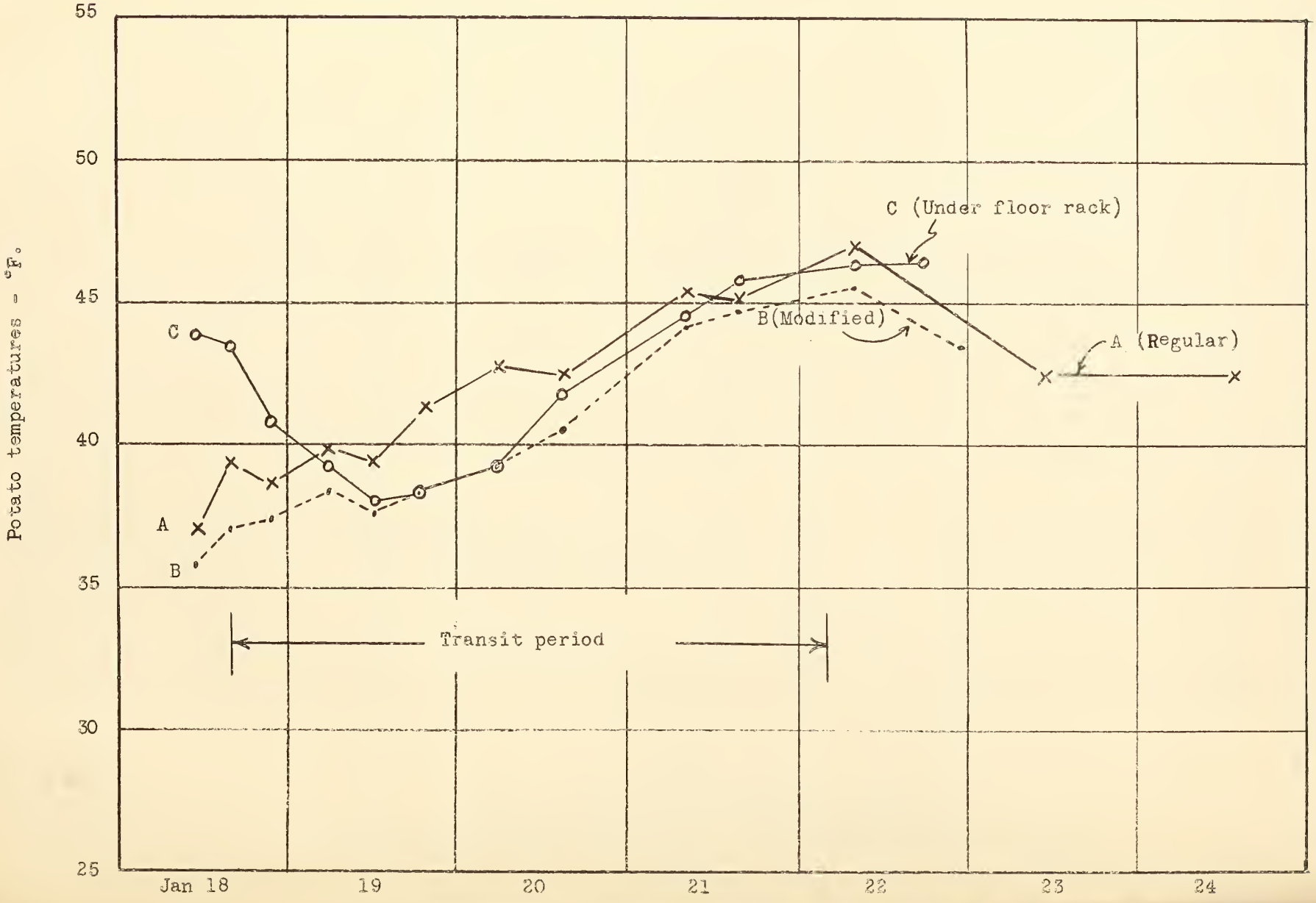


Figure 7

Comparison of average top and bottom layer potato temperatures in transit:
Regular and modified papered fan cars
with charcoal heaters - car fans off

Test 2

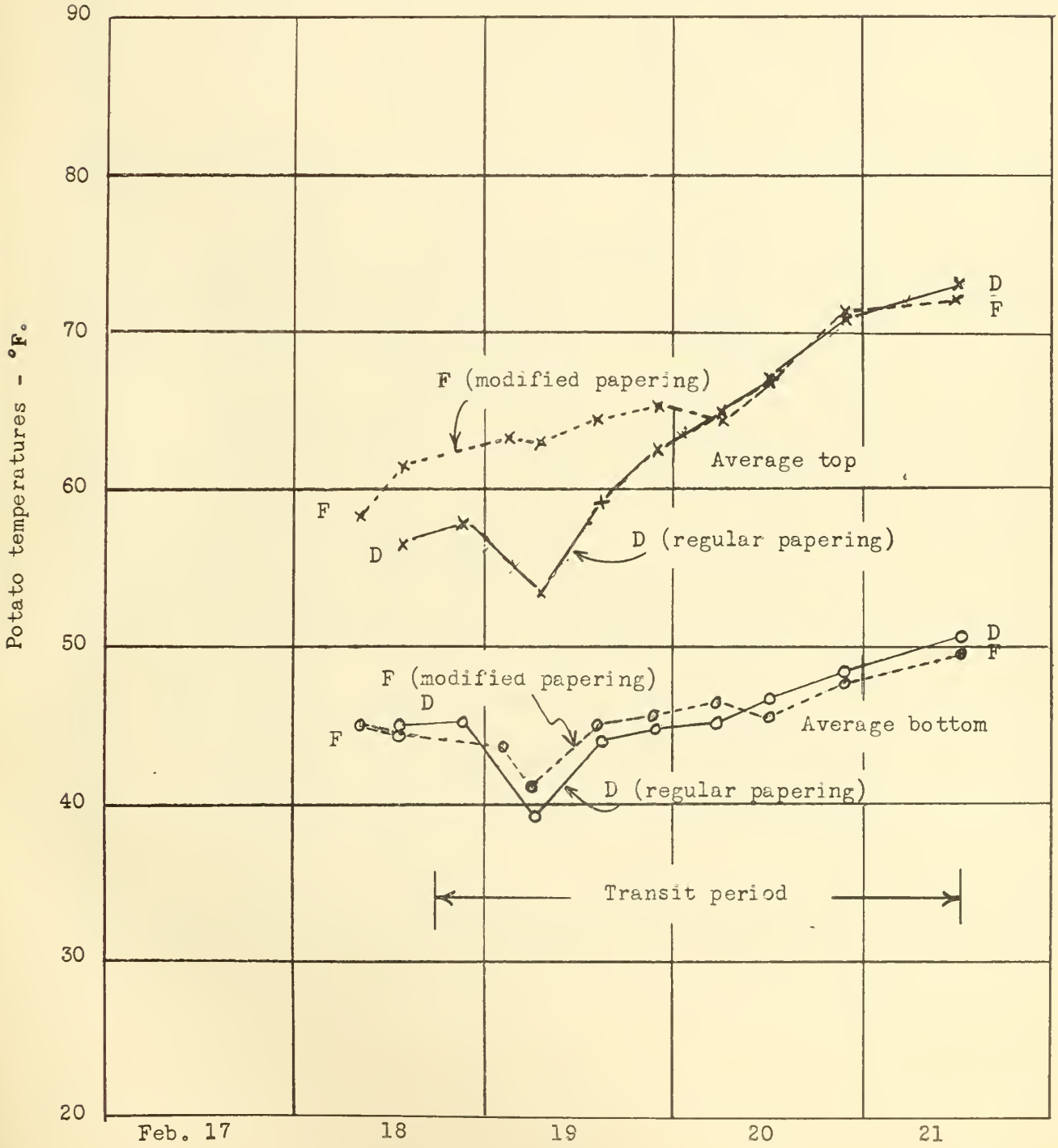


Figure 8

Average top and bottom layer potato temperatures in transit:
Regular and modified papered fan cars
with charcoal heaters - car fans on

Test 2

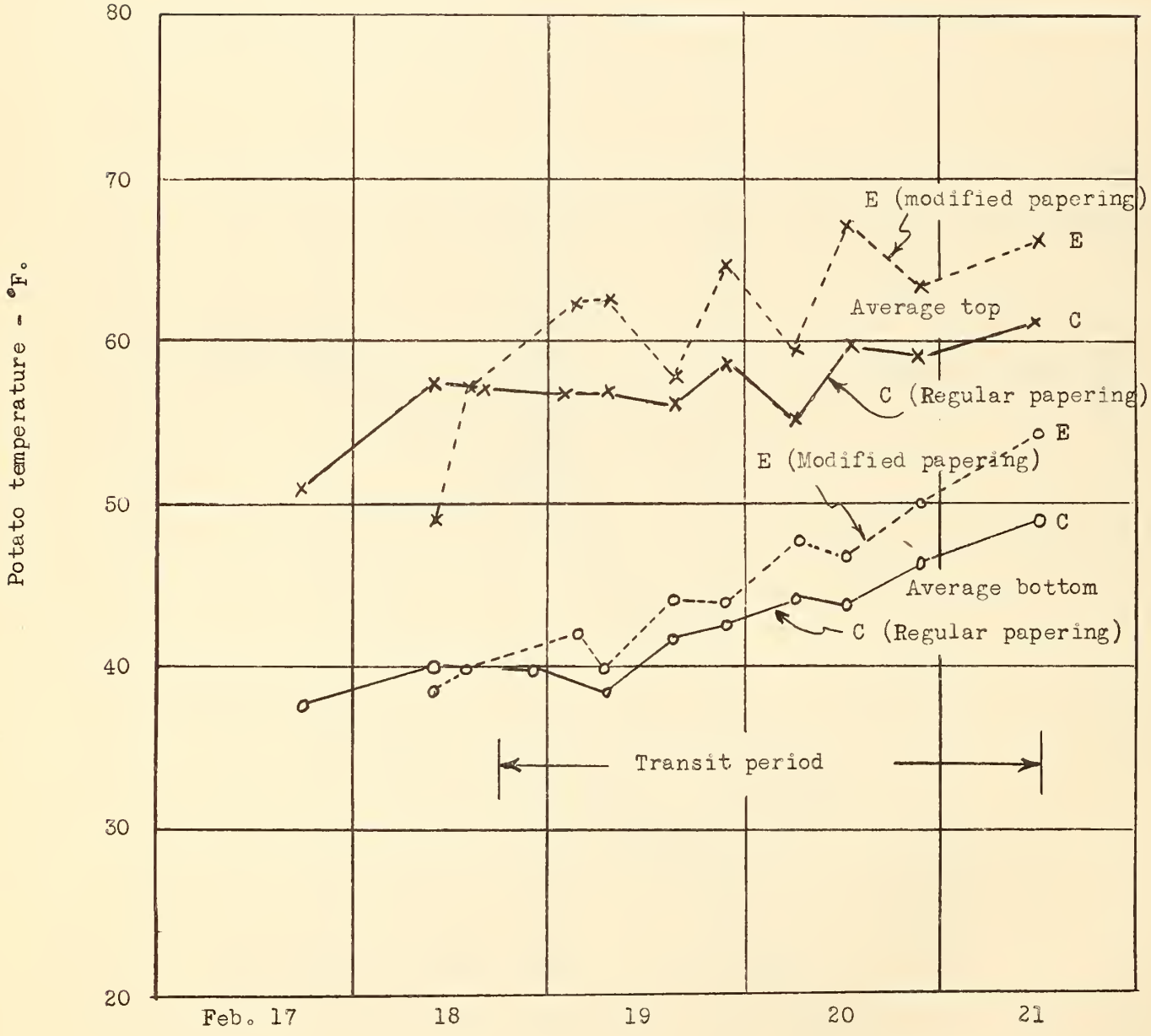


Figure 9

Comparison of average top and bottom layer potato temperatures in transit: Charcoal heaters (3 cars) alcohol heaters (3 cars) and underslung heater (1 car)

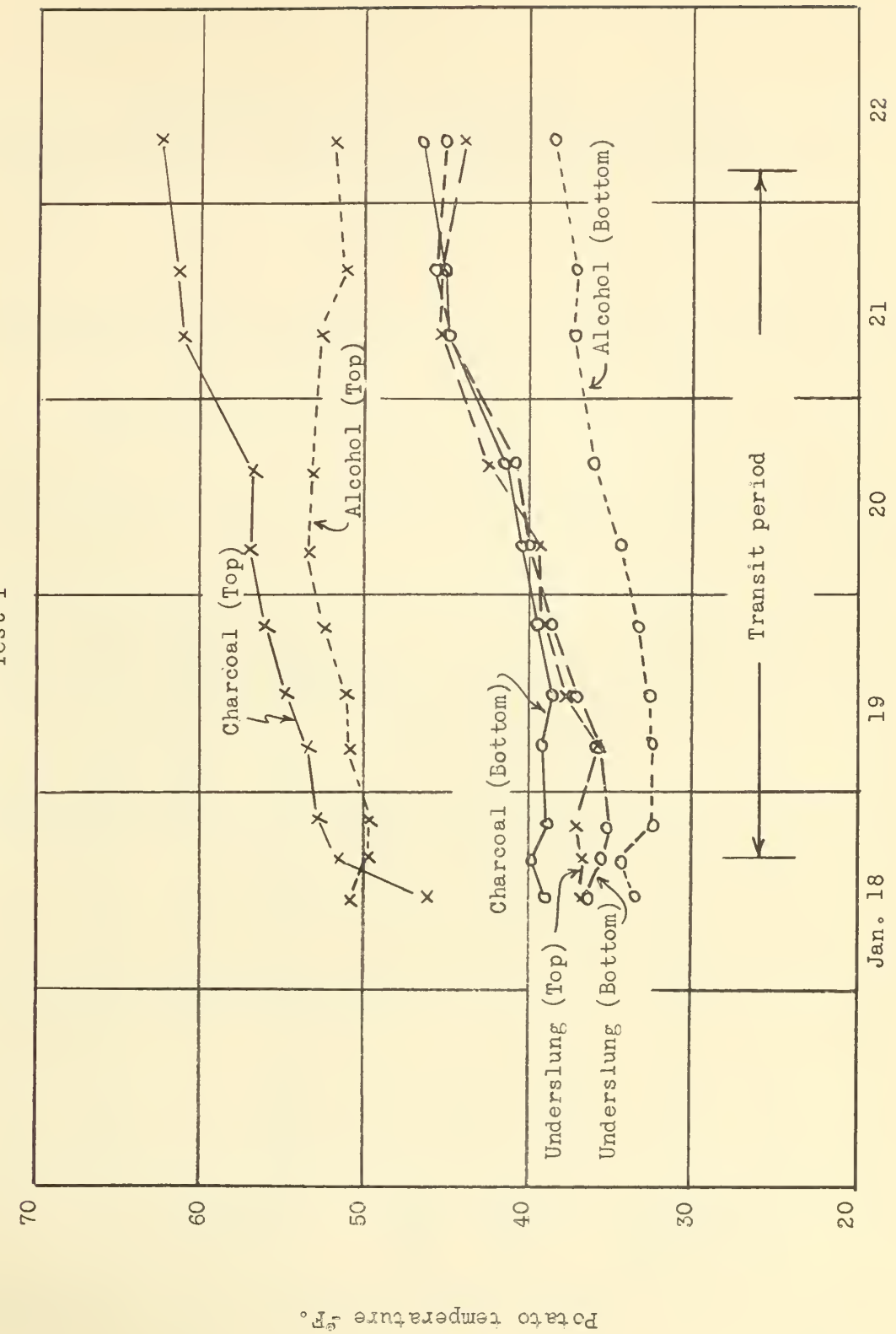


Figure 10

Comparison of average top and bottom potato temperatures in transit: Charcoal heaters (4 cars) and alcohol heaters (2 cars)

Test 2

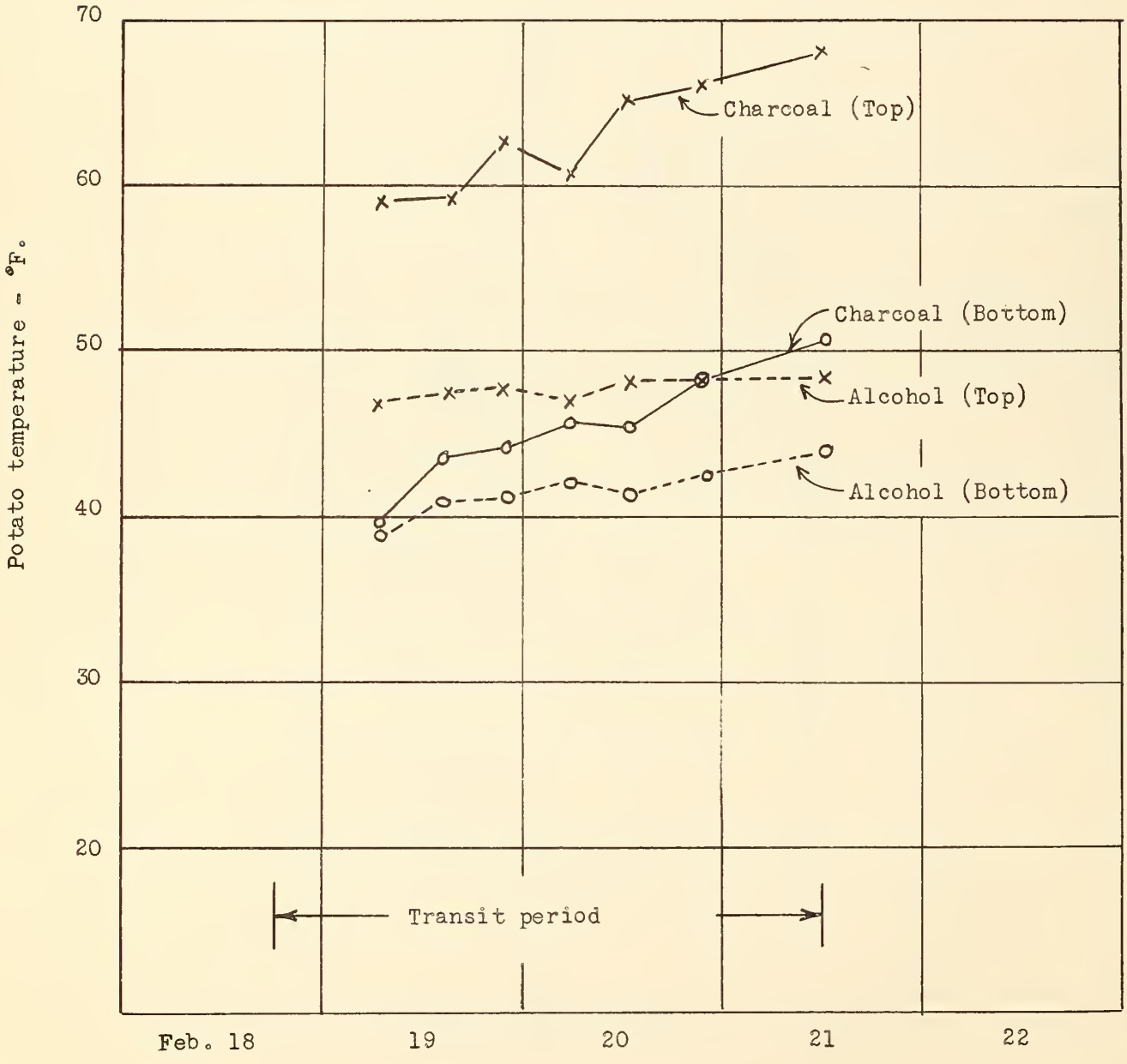


Figure 11

Comparison of average top and bottom layer potato temperatures in transit:
Regular papered fan cars with charcoal heaters
fans on and off

Test 2

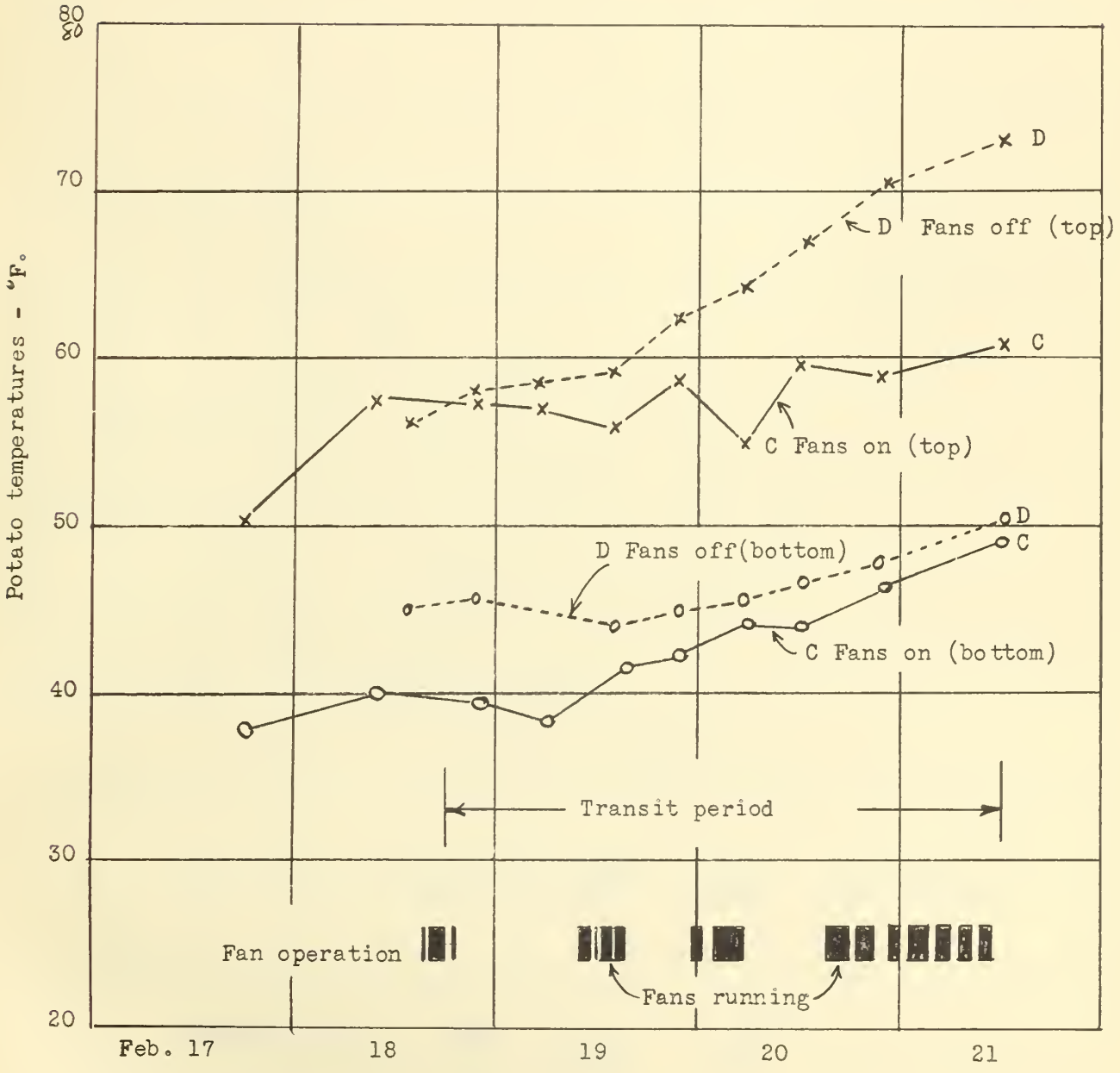


Figure 12

Comparison of average top and bottom layer potato temperatures in transit:
Modified papered fan cars with charcoal heaters
fans on and off

Test 2

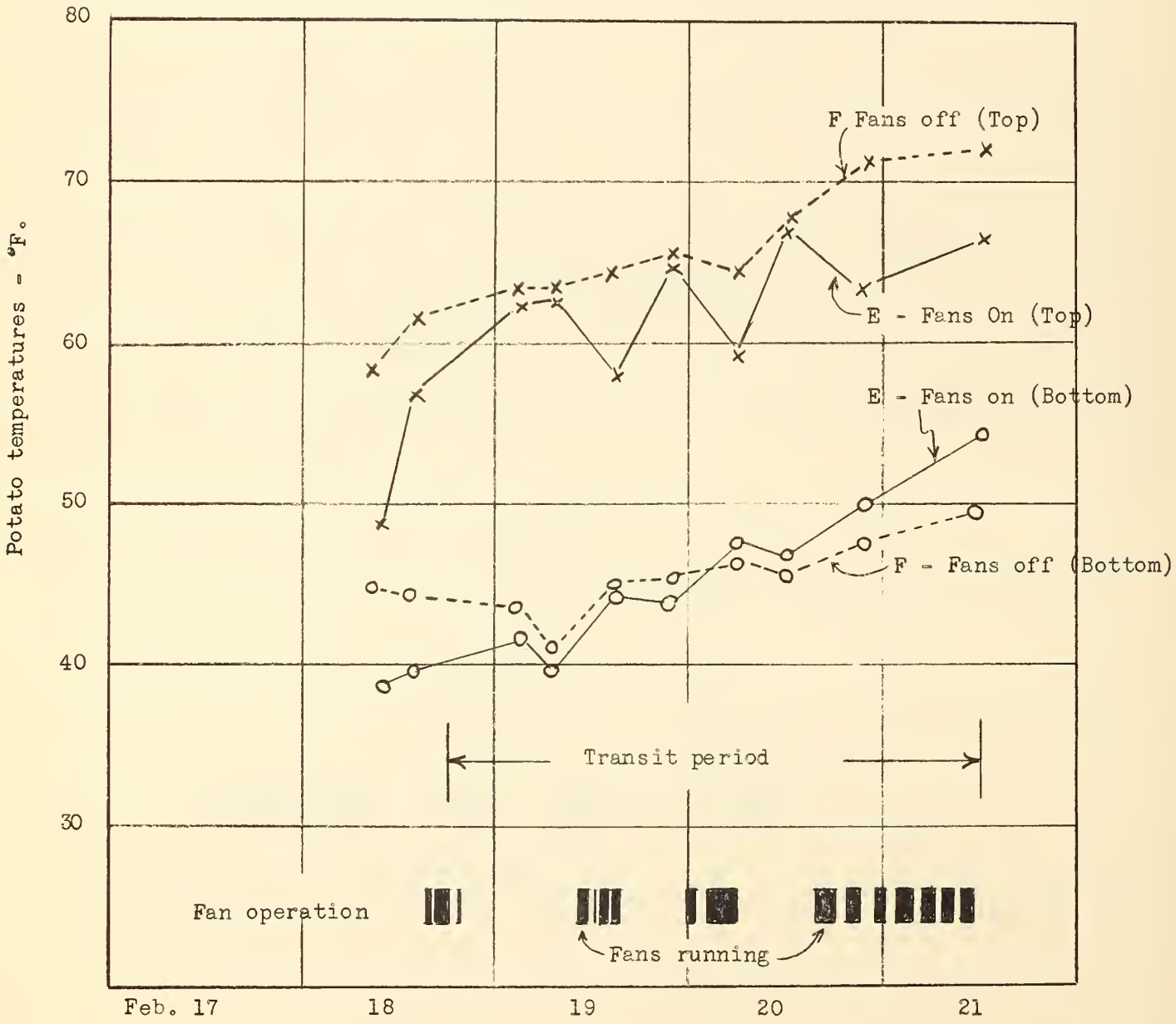


Figure 13

Comparison of average top and bottom potato temperatures in transit:
Regular papered fan cars with alcohol heaters
fans on and off

Test 2

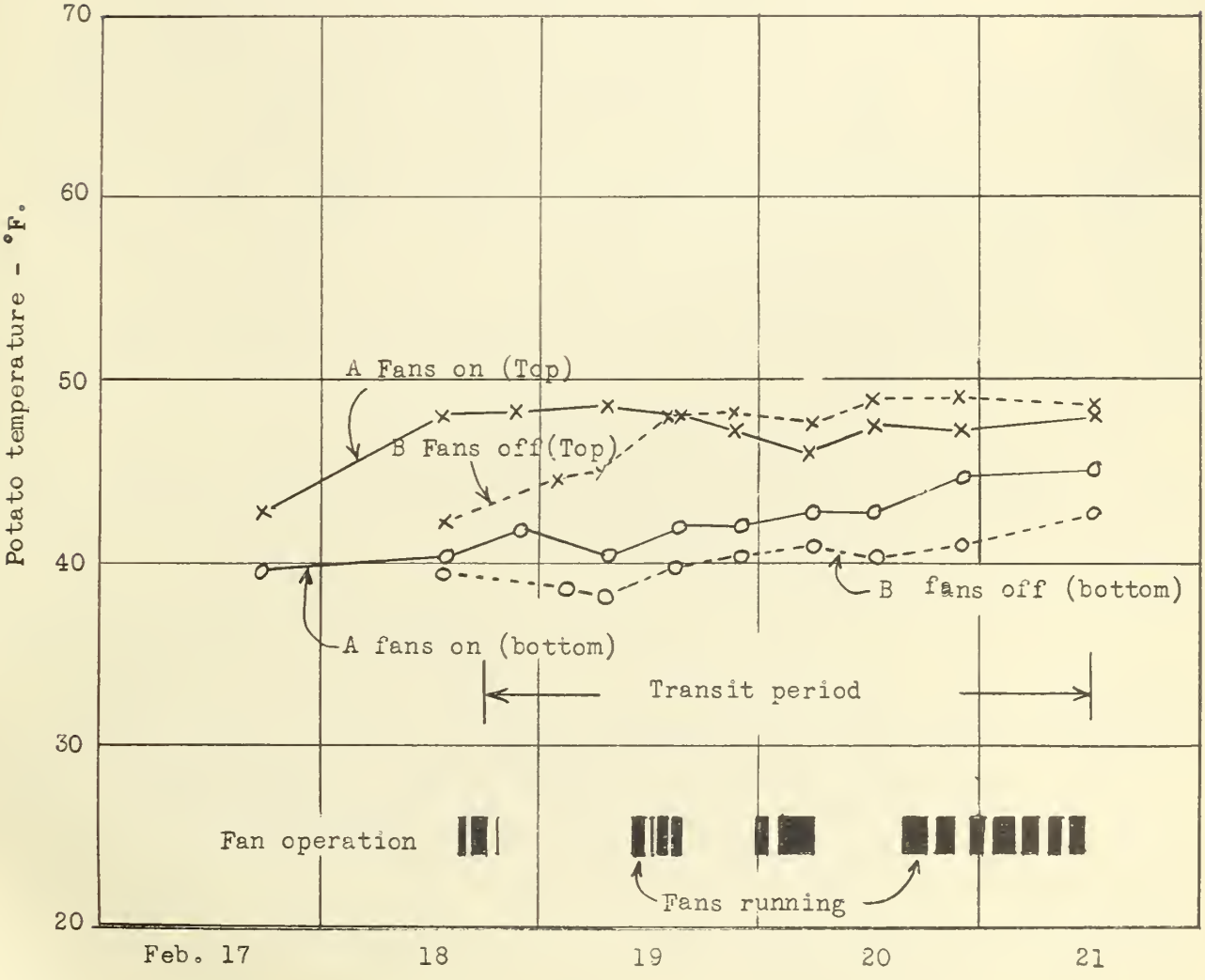


Figure 14

Comparison of average top and bottom potato temperatures in transit:
Regular papered fan cars with no heat
fans on and off

Test 2